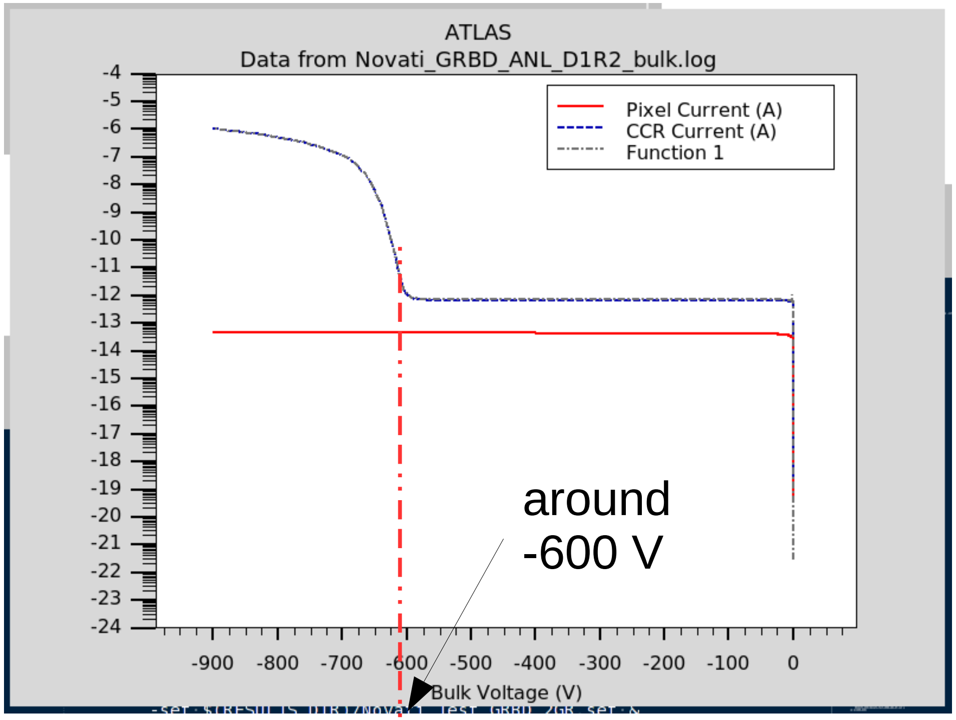
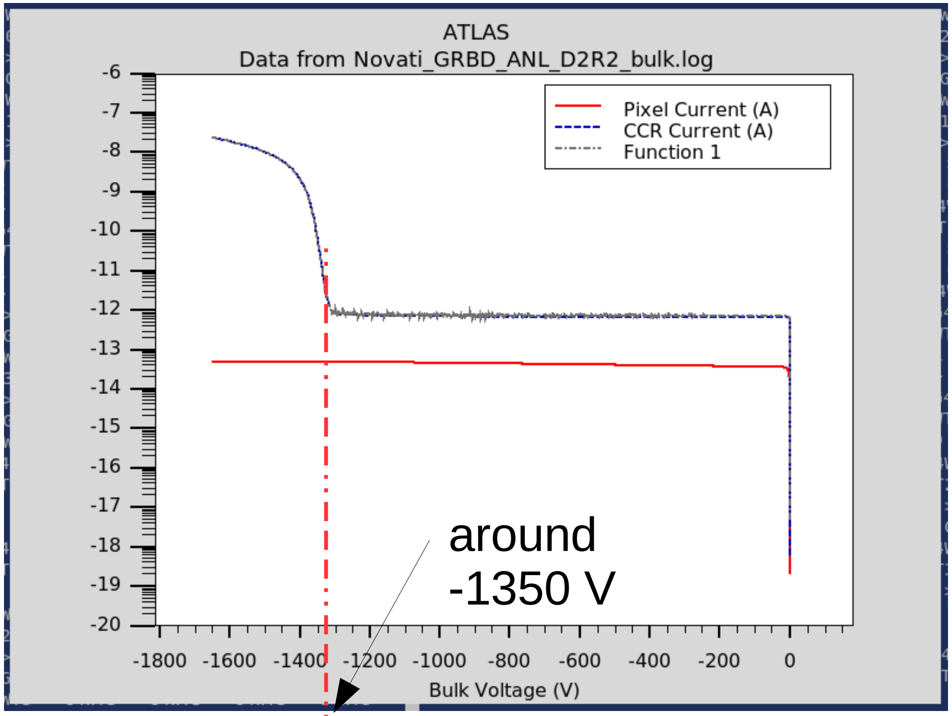
Sensor Naming

- D1 (Baseline device) [Left]
  - Classic design with 10 um p-stop width.
  - 15 Guard Rings after CCR
  - 15 um gaps.
- D2 [Right]
  - Revised design with 6 um p-stop width.
  - 12 um gaps.
  - Also 15 Guard Rings.

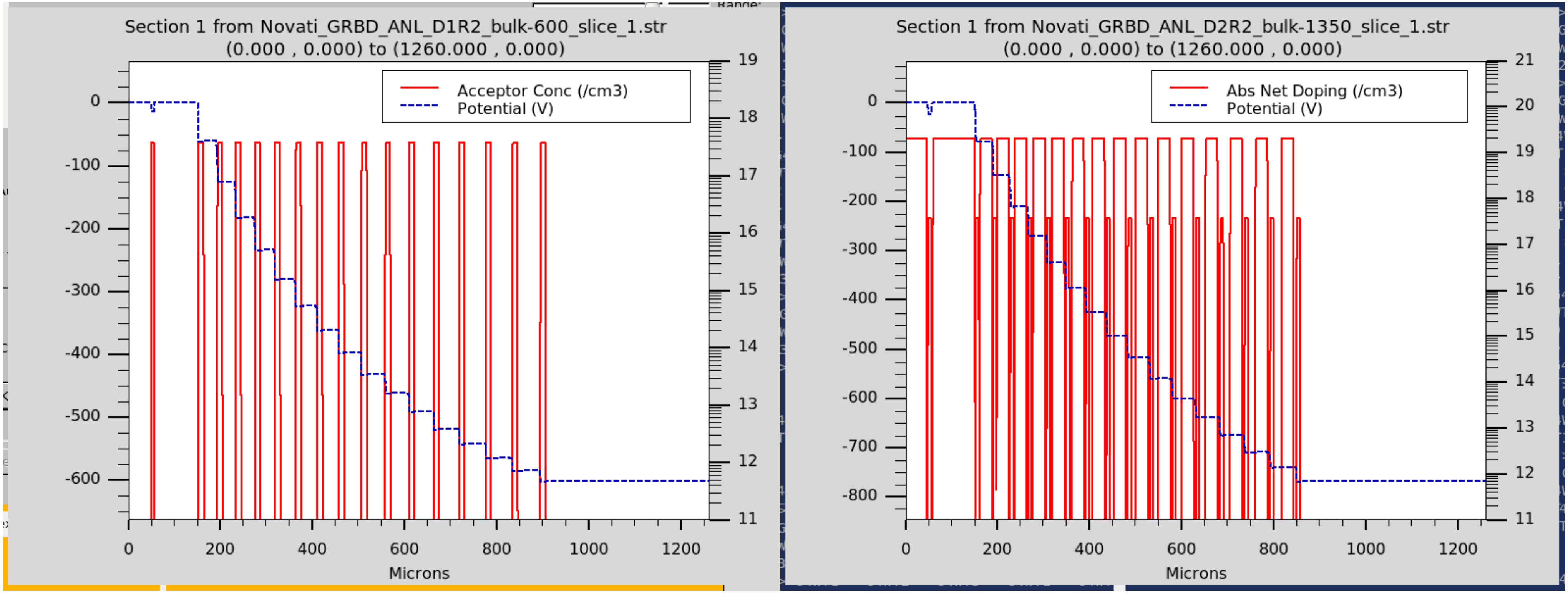
Breakdown Voltage





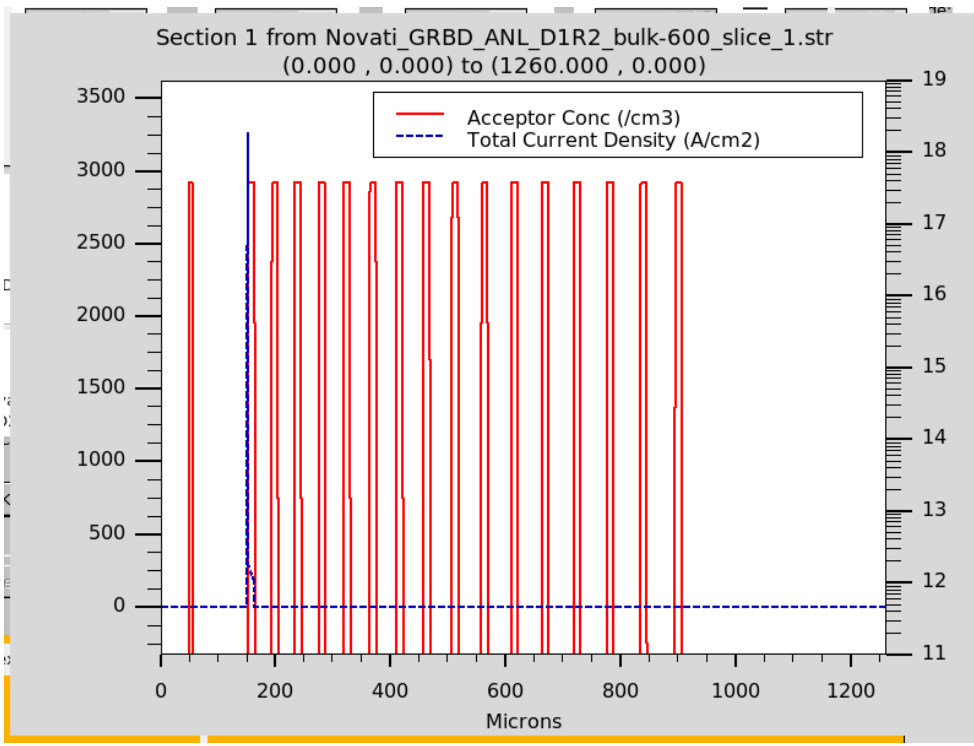
- D1 breaks down at ~ -600 V of bulk bias while D2 shows tremendous improvement in the breakdown voltage.
- Note that our operation voltage will be down to -900 V in this case: Thus, the old design may not be usable unless we thin down the substrate wafer.

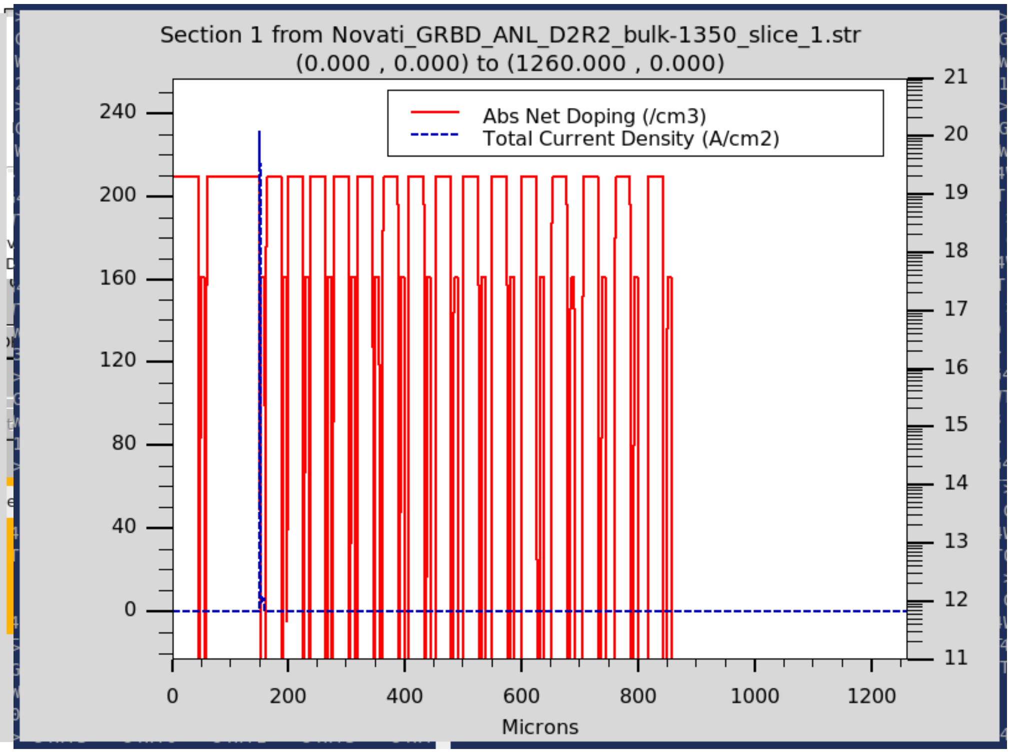
Surface Potential (Si)



- Potential drop profile are similar but the D2 actually drops down the edge potential much effectively to -780 V while D1 stays at -600 V.
- The CCR-GR1 potential drop at D1 stays at -60 V range while D2 stays at -80 V which is significantly lower (or higher in intensity.)

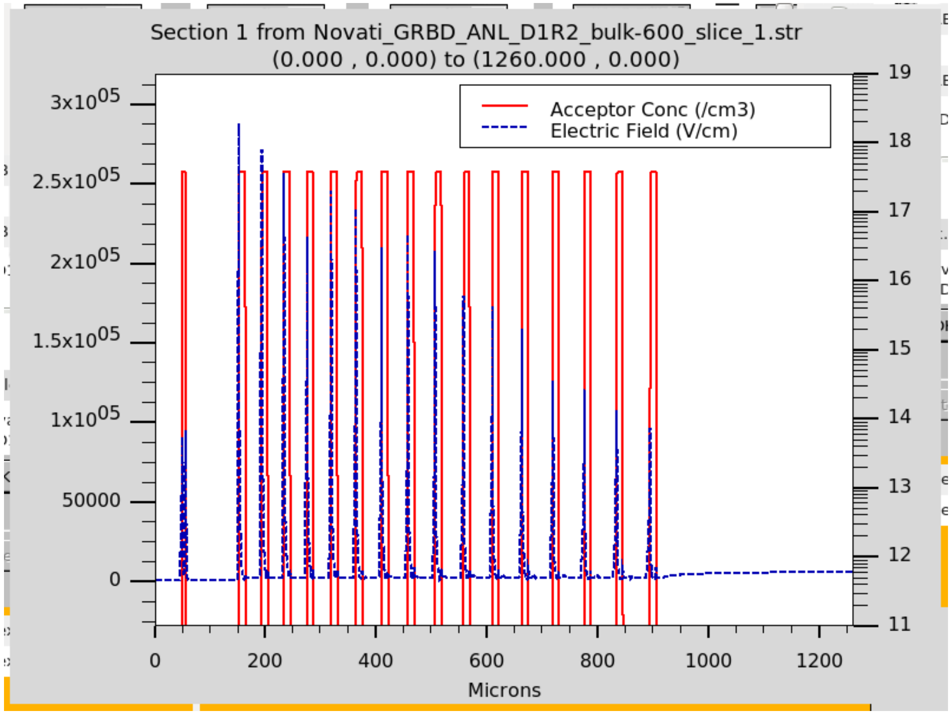
Breakdown Current Density

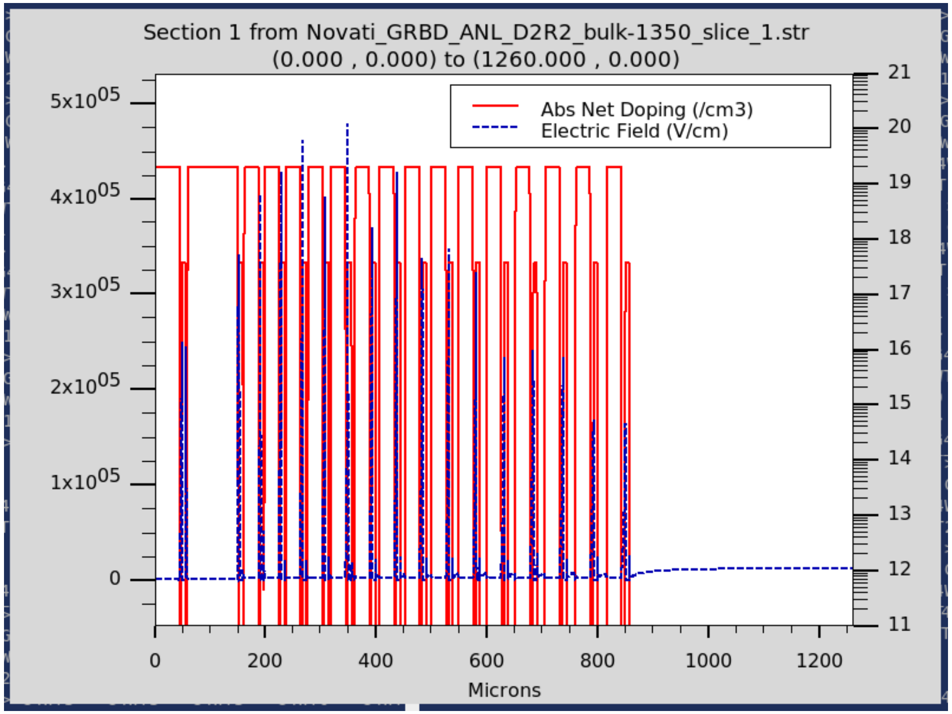




- As expected, the breakdown choke point is the p-stop between CCR-GR1.
- In other words, we need to bring down electric field at CCR-GR1 vicinity by playing with CCR electrode overhang and CCR contact – p-stop distance.

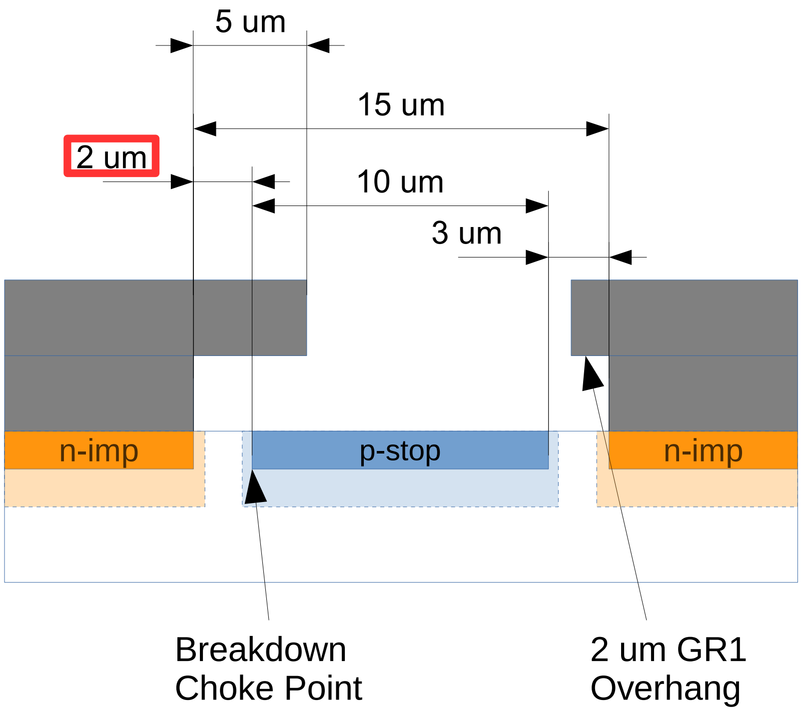
Electric Field at Si Surface

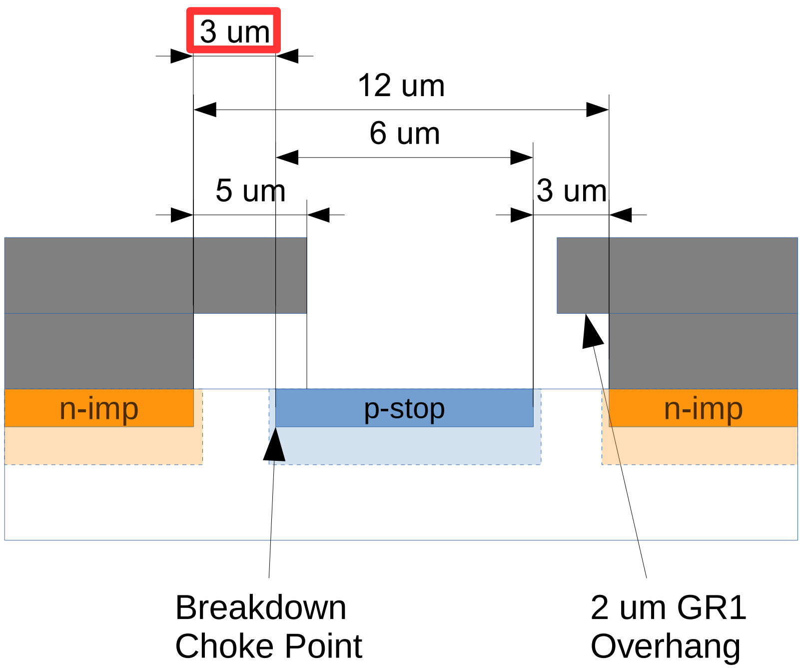




- The electric field at the n-implant – p-stop vicinity reaches up to 0.5 MV/cm in D2 (which is way after breakdown) while D1 shows even less than 0.3 MV/cm.
- In other words, the space between CCR implant and the first guard ring p-stop is a critical factor.
- D2 shows higher electric field at GR3-4 and 7-8 vicinity but the breakdown is actually happening at CCR-GR1.

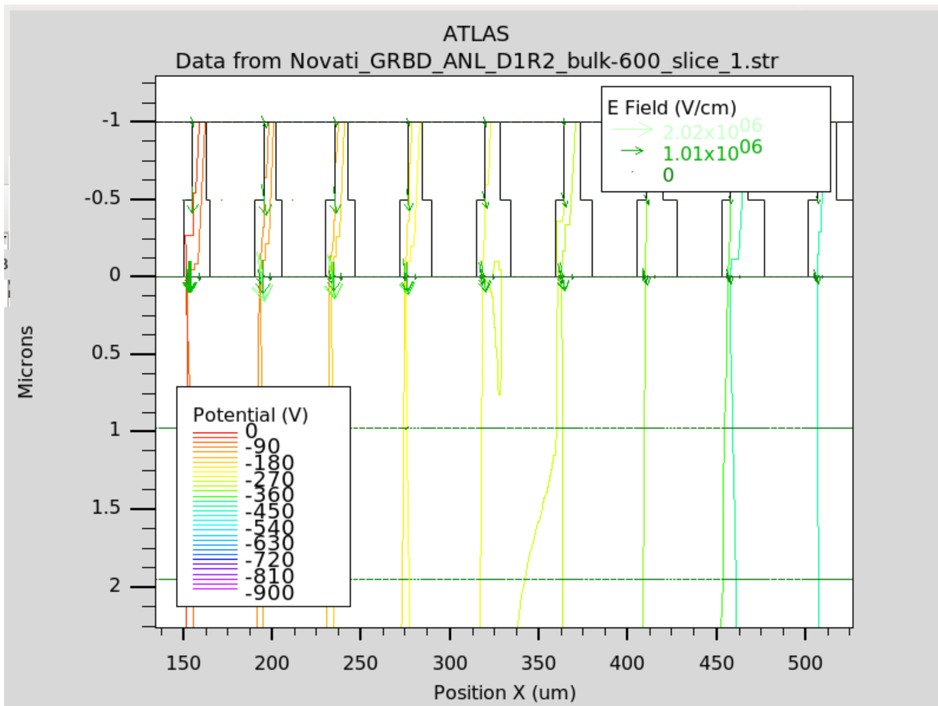
Dimension at CCR-GR1 Gap

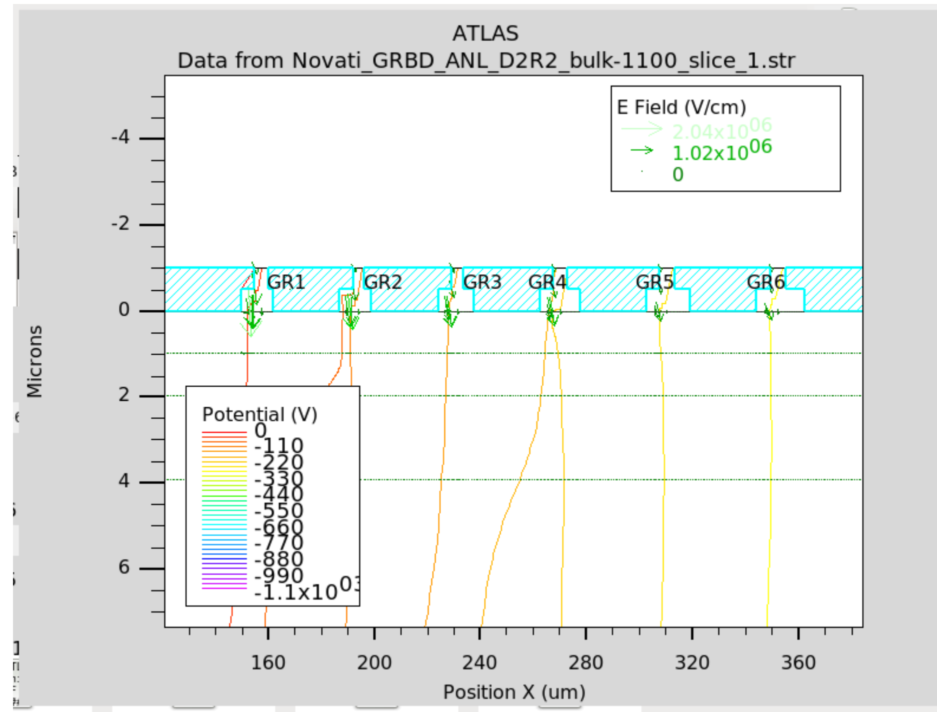




- At D2, we get 1 um of more space between CCR n-implant and the p-stop.
- Also, the diffused area (dotted area) further decreases the gap between n-implant and p-stop.
- Since the bias at CCR is higher than any other guard rings at n-in-p devices, we can reduce the p-stop and the GR n-implant gap which a positive bias is expected.
- If possible, we can reduce the p-stop width down to 5 um to give more space from the CCR n-implant and push the p-stop further from the CCR (by 1 um?) to even improve breakdown characteristics.

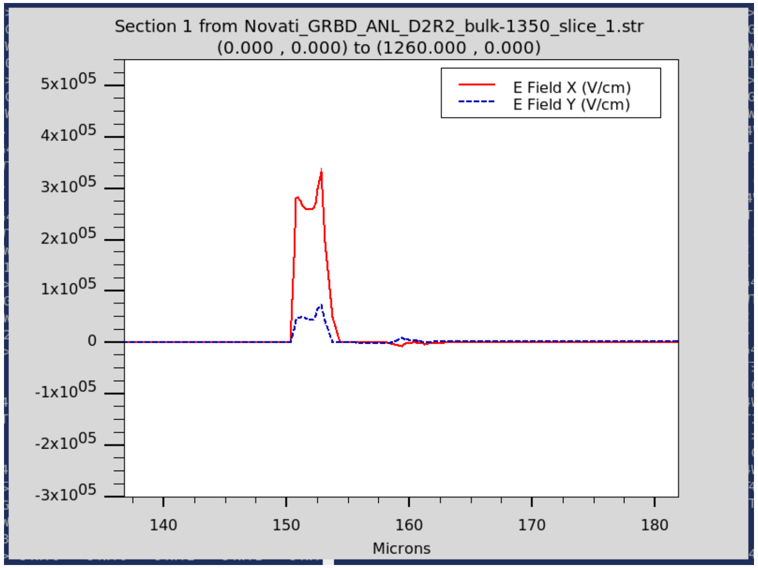
Electric Field Vector Plot

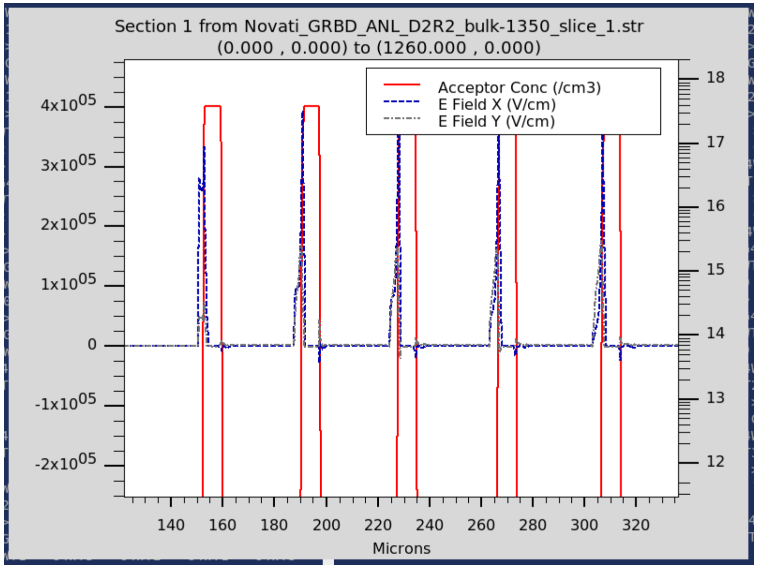




- It can be noted that the electrode overhang from previous guard ring, or CCR provides a tremendous vertical electric field through oxide.
- In the simulation, such electric field does not affect the electric field at p-stop vicinity too much.
- The vertical electric field at the vicinity is exceeding 1 MV/cm which may be OK if the silicon dioxide process was not compromised.

Vertical Portion of E-Field





- The vertical portion of electric field actually extends into the silicon.
- The Y portion of electric field at the 'choke point' is almost ¼ of the lateral electric field.
- Note that the other side, positive bias, has almost no electric field → no potential drop at all.
- The electric field extends almost up to 5 um between n-plus/p--/p-plus region.
- The breakdown (possibly avalanche) is mainly caused by electric field strength
- Thus, larger gap between n-implant and p-stop allows higher bulk bias to be applied at the bulk.
- On the other hand, the potential drop can be achieved by adding more p-stops.

Summary

- We need to provide more space at the reverse biased region at the p-stop implants to improve operation bias.
- The limiting factor is already set by the fabrication process: p-stop doping concentration.
- Thus, we can play with the n-implant/p-stop space and the number of p-stops.